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REQUIREMENTS FOR CRIMPING AND WIRE WRAP

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CHANGE 1
NHB 5300.4(3H)
Effective Date July 2, 1990

REQUIREMENTS FOR CRIMPING AND WIRE WRAP

1. This Change 1 reflects the following:

PAGE	CHANGE
18	Table 4-2, Page 18 - updates tensile strength values for wire barrel sizes 22 and 22D.

2. Remove page 17 and insert the attached pages.

3. Record receipt of this change on the Change Check List which should be filed in front of the Preface, page i.

4. This cover sheet may be retained.

DISTRIBUTION
SDL 1 (SIQ)

CHANGES CHECK LIST

CHANGE		POSTING	
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PREFACE

Date: May 1984

In order to maintain the high standards of the NASA crimp and wire wrap electrical connections programs, this publication:

Prescribes NASA's requirements for assuring reliable crimp and wire wrap electrical connections.

Describes and incorporates basic considerations necessary to assure reliable crimp and wire wrap electrical connections.

Establishes the supplier's responsibility to train and certify personnel.

Provides for supplier documentation of the fabrication and inspection procedures to be used for NASA work, including supplier innovations and changes in technology.

Provides visual workmanship standards to aid those responsible for determining quality conformance to the established requirements.

NASA Installations shall:

Invoke the provisions of this publication in procurements involving crimp and wire wrap electrical connections for aircraft, spacecraft, launch vehicles, mission essential support equipment, and elements thereof as appropriate to design or project requirements. Appendix A contains definitions for terminology used in this publication. Appendix B contains visual aids applicable to the processes contained in this publication.

Amend, when timely and within cost constraints, existing contracts to invoke the requirements of this publication.

Utilize the provisions of this publication as a basis for fabricating crimp and wire wrap electrical connections and, as necessary, for the training and certification of in-house personnel.

Assure that NASA contractors invoke the provisions of this publication in their subcontracts and purchase orders.

Make available copies of this publication, in the quantities required, to NASA contractors, subcontractors, and suppliers.

Questions concerning application of this publication to specific procurements shall be referred to the procuring NASA installation or its designated representative.

This publication shall not be rewritten or reissued in any other form.

Milton A. Silveira
Chief Engineer

DISTRIBUTION:

SDL 1 (SIQ)

ORGANIZATION OF THE R&QA MANUAL

OVERALL COVERAGE

The Reliability and Quality Assurance Manual - referred to as the "R&QA Manual" - is the overall generic title which identifies all NASA R&QA management publications published under the basic R&QA subject classification code. The publications are grouped by major subject breakdown and further divided into specific categories identified as Parts. These Parts (not a complete R&QA Manual) are published as individual R&QA publications.

The following list shows the grouping and R&QA publications:

Title	Number
Volume 1 - General Provisions	
Reliability Program Provisions for Aeronautical and Space System Contractors	NHB 5300.4(1A) (April 1970)
Quality Program Provisions for Aeronautical and Space System Contractors	NHB 5300.4(1B) (April 1969)
Inspection System Provisions for Aeronautical and Space System Materials, Parts, Components and Services	NHB 5300.4(1C) (July 1971)
Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program	NHB 5300.4(1D-2) (October 1979)
Volume 2 - Government Agency Provisions	
Management of Government Quality Assurance Functions for Supplier Operations	NHB 5330.7 (April 1966)
Quality Assurance Provisions for Government Agencies	NHB 5300.4(2B) (November 1971)
Volume 3 - Standards	
Requirements for Soldered Electrical Connections	NHB 5300.4(3A-1) (December 1976)

Qualified Products Lists Requirements for Microcircuits	NHB 5300.4(3F) (June 1972)
Requirements for Interconnecting Cables, Harnesses, and Wiring	NHB 5300.4(3G) (soon to be released)
Requirements for Crimping and Wire Wrap	NHB 5300.4(3H) (May 1984)
Requirements for Printed Wiring Boards	NHB 5300.4(3I) (May 1984)
Requirements for Conformal Coating and Staking of Printed Wiring Boards and Electronic Assemblies	NHB 5300.4(3J) (soon to be released)

DOCUMENT REFERENCING

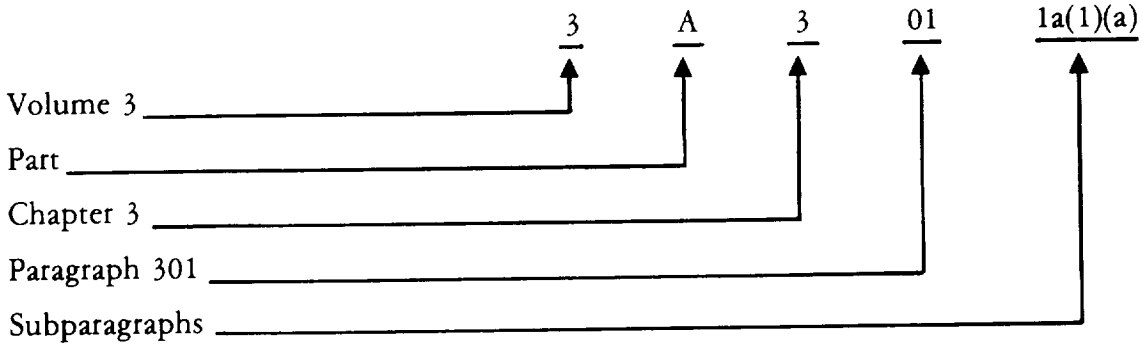
Each R&QA Manual Part is assigned its own identification number within the basic classification code. The numeric-alpha suffix within a parenthesis identifies the grouping of the publication, that is, the volume and part, such as NHB 5300.4(3A): This number indicates that this is the first "Standards" (Volume 3) publication to be issued.

When a part is revised, the suffix identification will be changed to indicate the revision number, such as NHB 5300.4(3A-1).

In referencing or requesting any R&QA publication, the complete specific NHB number must be used.

PARAGRAPH REFERENCING

1. **Within the R&QA Manual.** The following shows the paragraph numbering system applicable to all R&QA publications.



This system provides for referencing any R&QA publication requirement (paragraph) in any other R&QA publication without the need for identifying the NHB number, title, the volume number, or part. However, when referencing a complete Part within another R&QA publication, the specific NHB number must be used.

2. **In Other NASA Documents.** When it is necessary to reference an R&QA publication requirement (paragraph) in any other NASA document, the specific NHB number and paragraph number must be used together as follows: "NHB 5300.4(3A-1), paragraph 3A301-1a(1)(a)," or "paragraph 3A301-2b of NHB 5300.4(3A-1)."

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CHAPTER 1: BASIC PRINCIPLES

3H100 APPLICABILITY AND SCOPE

1. **Applicability.** This publication is applicable to NASA programs involving interconnecting cabling and wiring harnesses for aircraft, spacecraft, launch vehicles, mission essential support equipment, and elements thereof, and where invoked contractually in procurements.

2. **Scope.** This publication sets forth requirements for reliable crimp and wire wrap electrical connections.

3. **Special Requirements.** Special requirements may exist which are not covered by or are not in conformance with the requirements of this publication. *Design documentation shall contain the detail for such requirements, and they shall take precedence over conflicting portions of this publication when they have been approved in writing by the procuring NASA installation.*

3H101 PRINCIPLES OF RELIABLE CRIMPING AND WIRE WRAP

1. **Factors Controlling Reliability.** Reliable crimp and wire wrap electrical connections result from proper design, control of tools, materials, work environments and workmanship.

3H102 GENERAL

1. **Implementation.** NASA quality assurance personnel will advise and assist contractors, suppliers, NASA personnel, and delegated agencies in the proper and effective implementation of the provisions of this publication. Effective implementation includes establishing a system which will identify each inspection point and provide a record.

2. **Changes in Requirements.** When related requirements or changes in requirements are specified, NASA quality assurance personnel will assure that the Government agency delegated to inspect at the supplier's site of fabrication has received full instructions so that the work will be inspected to actual contract requirements.

3. **Internal Connections.** Unless parts are manufactured specifically to comply with contracts or subcontracts citing this publication, internal connections of parts (parts are defined in Appendix A) are not subject to the requirements of this publication. The supplier shall assure that parts have suitable internal crimp and wire wrap electrical connections which will not deteriorate with time and/or environmental exposure.

4. **Nonstandard Processes, Materials, or Connections.** When the supplier intends to make crimped or wire wrapped electrical connections using processes, materials, or connections not covered by this publication, the supplier shall document the details of fabrication and inspection, including acceptance and rejection criteria, and provide appropriate test data. Such documentation shall be approved by the procuring NASA installation prior to use.

3H103 RELATED DOCUMENTS

1. **Applicable Specifications.** Copies of the following specifications, when required in connection with a specific procurement, may be obtained from the procuring NASA installation or as directed by the contracting officer:

Federal Specifications:

O-T-620, "1,1,1-Trichloroethane Technical, Inhibited (Methyl Chloroform)."

QQ-N-290, "Nickel Plating (Electrodeposited)."

Military Specifications:

MIL-C-22520, "Crimping Tools, Terminal, Hand or Power Actuated, Wire Termination, and Tool Kits, General."

MIL-G-45204, "Gold Plating (Electrodeposited)."

MIL-P-81728, "Plating, Tin Lead (Electrodeposited)."

MIL-W-81822, "Wire, Electrical, Solderless Wrap, Insulated and Uninsulated."

2. **Other Publications:**

NASA NHB 5300.4 (3G), "Requirements for Interconnecting Cables, Harnesses, and Wiring," (soon to be released).

OSHA Standards, Title 29 Code of Federal Regulations, Part 1910 (and State Standards as applicable).

Unless otherwise specified, the issue in effect on the date of invitation for bids or requests for proposal shall apply.

3H104 DEVIATION AND WAIVER REQUESTS

1. **Approval of Changes.** This publication requires that:

   a. Written approval shall be obtained from the cognizant NASA Contracting Officer or designated NASA Representative for technical changes, deviations, or waivers initiated by the supplier.

   b. All deviation and waiver requests shall be supported by objective evidence, and data substantiating that quality and reliability will not be compromised.

2. **Responsibility.** The prime contractor is responsible for assuring that any departures from this publication are evaluated, coordinated with, and submitted to the procuring NASA installation for approval prior to use or implementation.

3H105 REWORK

Rework is permissible unless excluded by other provisions of the contract. All rework shall meet the requirements of this publication. Rework is not repair. Repair shall be made only in compliance with applicable contractual requirements.

3H106 DEFINITIONS

For the purposes of this publication, the definitions in Appendix A shall apply.

CHAPTER 2: SUPPLIER CRIMP AND WIRE WRAP ELECTRICAL CONNECTION PROGRAM

3H200 GENERAL

The supplier is responsible for maintaining a documented crimp and wire wrap electrical connection program which meets the requirements of this publication. Portions of this publication may be abstracted for the supplier's program.

3H201 TRAINING AND CERTIFICATION

The supplier is responsible for:

1. Assuring that design personnel are familiar with the requirements of this publication and other pertinent requirements of the contract or purchase order.

2. Providing necessary training of manufacturing, assembly, and inspection personnel to include familiarization with connection design, crimp and wire wrap assembly techniques, equipment used, and procedures pertinent to the areas of responsibility of each in performance of their duties. Make applicable standards readily available to all personnel and use them in the training program.

3. Assuring that each individual who assembles or inspects crimp or wire wrap electrical connections is appropriately skilled in the types of connections involved in the assigned work.

4. Assuring that each individual who assembles or inspects crimp or wire wrap connections is currently certified to all requirements of this publication pertaining to the types of connections involved in the assigned work. Demonstration of proficiency is a prerequisite for such certification. Records or evidence of certification status shall be maintained in the work area.

5. Maintaining appropriate records of certification criteria and training.

3H202 MAINTENANCE OF CERTIFIED STATUS

1. **Proficient Workmanship.** The procuring NASA installation, its designated representative, or the supplier may require supplier assembly personnel to demonstrate proficient workmanship on applicable hardware or to be recertified.

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2. **Proficient Inspection.** The procuring NASA installation, its designated representative, or the supplier may require supplier inspection personnel to demonstrate proficient inspection performance and knowledge on applicable hardware or to be recertified.

3H203 RECERTIFICATION

1. **Causes for Recertification.** Recertification shall be required when:

   a. Proficiency requirements herein are not met. The need for recertification shall be based on observation of the unsatisfactory quality of articles either fabricated by an assembler or accepted by an inspector.

   b. New techniques have been developed which require different skills.

   c. Individual changes employment.

   d. The type of work requiring certification is interrupted for more than 90 days and operator or inspector fails to demonstrate required proficiency.

2. **Recertification Procedures.** Procedures for recertification shall include sufficient training or retraining to enable the candidate to demonstrate proficiency in fabricating or inspecting the types of crimp and wire wrap electrical connections involved in the assigned work. A proficiency demonstration shall be required of each candidate.

3H204 REVOCATION OF CERTIFIED STATUS

Certification shall be revoked for operators or inspectors when:

1. Certificate holder requires recertification according to paragraph 3H203 and fails to be recertified.

2. Certificate holder fails to meet visual acuity requirements of paragraph 3H205.

3. Certificate holder leaves employment.

4. Supplier training program fails to meet requirements set forth herein or set forth otherwise in the contract.

3H205 VISION REQUIREMENTS

1. **Supplier Responsibility.** Supplier is responsible for assuring that all personnel who perform assembly or inspect crimp and wire wrap electrical connections meet the following vision test requirements as a prerequisite to training, certification, and recertification. The vision requirements may be met with corrected vision (personal eyeglasses). However, any correction necessary to meet vision requirements shall be documented on the certificate. Where work is performed under a microscope, suitable verification of necessary visual acuity shall be made. The eye tests shall be administered by qualified personnel using standard instruments and techniques. Results of the visual examinations shall be maintained and kept available for review.

2. **Minimum Vision Requirements.** The following are the minimum vision requirements:

   a. Far vision: Snellen Chart 20/50.

   b. Near vision: Jaeger 1 at 14 inches, reduced Snellen 20/20, or equivalent.

   c. Color vision: Ability to distinguish red, green, blue, and yellow colors as prescribed in Dvorine Charts, Ishihara Plates, or American Optical Company-Hardy, Rand, Ritter (AOC-HRR) Tests. A practical test using color-coded wires and/or color-coded electrical parts, as applicable, will be acceptable for color vision testing.

3H206 WORKMANSHIP STANDARDS

The supplier shall:

1. Utilize visual standards consisting of satisfactory work samples or visual aids which clearly illustrate the quality characteristics for crimp and wire wrap electrical connections applicable to the contract or purchase order.

2. Use applicable illustrations in this publication, supplemented as necessary for visual standards. Standards of unacceptable conditions may also be used for clarification or comparison.

3. Prepare appropriate work samples or visual aids for approved connections other than those illustrated herein.

4. Make applicable standards readily available to personnel involved and use these standards in the training program.

3H207 DOCUMENTATION

1. **Applicable Documents.** Documents required herein shall be submitted to the procuring NASA installation or its designated representative as required by the contract or purchase order. Applicable supplier crimp and wire wrap documents, or portions thereof, accepted on other NASA contracts shall be included to avoid duplication of effort.

2. **Training and Certification Programs.** The supplier shall describe the proposed training certification programs to satisfy the requirements herein for the types of crimp and wire wrap electrical connections to be made. This description shall include the following, as applicable:

   a. Qualification of instructors.

   b. Procedures for training, including who will be trained and for what function, i.e., fabricator, inspector, or other personnel.

   c. Lesson plan(s).

   d. Hours of instruction.

   e. Procedures for certification and recertification.

   f. Procedures for recording of training, recertification, and method of identifying trained personnel.

   g. Certification criteria.

3. **Process Methods and Procedures.** The supplier shall document the methods and procedures proposed to incorporate the requirements of this publication into the design, fabrication, and inspection of crimp or wire wrap electrical connections involved in the contract or purchase order.

CHAPTER 3: FACILITIES, EQUIPMENT, AND MATERIALS

3H300 FACILITY CLEANLINESS

The supplier is responsible for maintaining assembly/fabrication areas in a clean, orderly condition. Smoking, eating, and drinking at the work stations shall not be permitted.

3H301 ENVIRONMENTAL CONDITIONS

1. **Controlled Environments.** The assembly area shall have a controlled environment which limits the entry of contamination. The temperature and humidity of this area shall be continuously maintained within the limits defined as the comfort zone in Figure 3-1.

2. **Forced Ventilation or Exhaust.** Forced ventilation or exhaust shall be provided in areas where operations such as part cleaning and vapor degreasing are being performed.

3. **Critical Environmental Conditions.** When the parts or equipment being processed require more critical environmental conditions than the preceding, the requirements shall be identified and specified in the design documentation. Such requirements will take precedence over the established controlled environments.

3H302 LIGHTING REQUIREMENTS

Light intensity shall be a minimum of 100 foot-candles (1076.4 lumens/m^2) on the surface of the crimping or wire wrapping operations.

3H303 TOOL AND EQUIPMENT CONTROL

The supplier shall:

1. Select appropriate tools and equipment used in manufacturing crimp or wire wrap electrical connections for the intended function.

2. Properly clean and maintain equipment and tools.

3. Document or reference detailed operating procedures and maintenance schedules for tools and equipment requiring calibration or setup in the supplier's crimp or wire wrap electrical connection program.

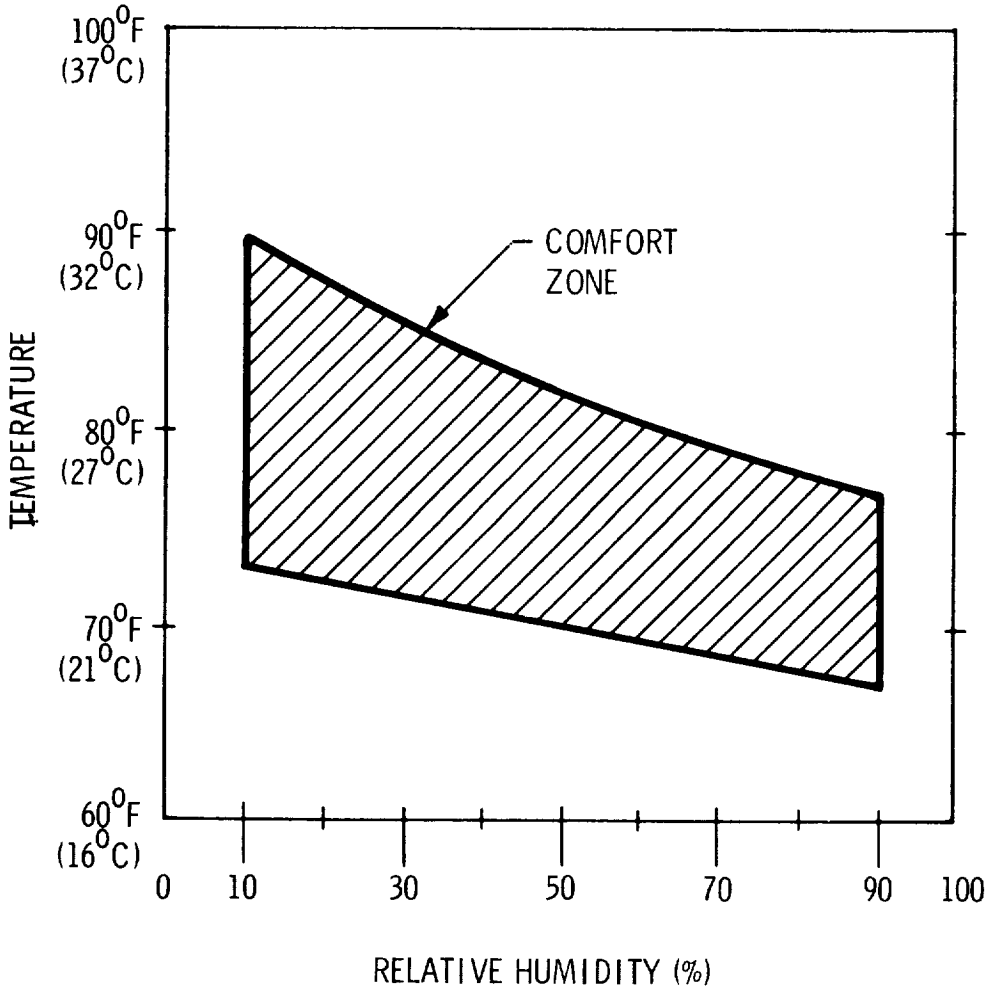


FIGURE 3-1
COMFORT ZONE:
TEMPERATURE VERSUS HUMIDITY REQUIREMENTS

4. Maintain records of tool and equipment calibration and verification.

5. Prohibit the presence of unauthorized, defective, or out-of-calibration tools in the work area.

6. Implement a system to control and record issue and recall of crimp and wire wrap tools to assure that tools not required to perform assigned manufacturing operations are not in the immediate work area.

7. Store tools that are not to be immediately used to perform assigned manufacturing operations in such a manner as to preclude tool damage or inadvertent usage.

3H304 CONDUCTOR PREPARATION TOOLS

The supplier shall select and use conductor preparation tools as follows:

1. Select insulation strippers which do not nick, ring, gouge, or scrape conductors or otherwise damage parts.

2. Use the correct size of stripping tools or machines and maintain them in proper operation. Method, interval, and status shall be documented by the supplier.

3. Verify proper operation of insulation strippers periodically.

4. Remove defective tools promptly from the work area.

3H305 IN-PROCESS STORAGE AND HANDLING

1. **Damage Control Measures.** The supplier shall develop and implement requirements and procedures necessary to prevent damage and shall control conditions that could degrade the reliability of parts and deliverable items. In particular, means shall be provided to prevent damage to or contamination of termination components, connectors or wire ends during handling and storage. Containers shall be compatible with the materials stored.

2. **Metal Surfaces.** If metal surfaces become contaminated, they shall be cleaned immediately using a solvent specified in paragraph 3H307.

3. **Static-Sensitive Parts and Assemblies.** Static-sensitive parts and assemblies shall be identified and handled with proper precautions.

3H306 MATERIALS SELECTION

The supplier shall select materials that will meet the performance requirements of this document.

3H307 SOLVENTS

1. **Solvent Selection.** Solvents shall be nonconductive and noncorrosive, and shall not dissolve parts or degrade the quality of parts or materials. Solvents shall be properly labeled and shall be maintained in a clean and uncontaminated condition. Those showing evidence of contamination or decomposition shall not be used.

> **CAUTION!**
>
> SOLVENTS SHALL NOT BE USED IN ANY MANNER WHICH WILL CARRY TO OR DEPOSIT RESIDUE ON CONTACT SURFACES SUCH AS THOSE IN SWITCHES, POTENTIOMETERS, OR CONNECTORS.

2. **Acceptable Solvents.** Only the following solvents are acceptable when used for cleaning:

   a. Ethyl alcohol, ACS grade, 99.5 percent or 95 percent by volume.

   b. Isopropyl alcohol, best commercial grade, 99 percent pure.

   c. Trichlorotrifluoroethane, clear, 99.8 percent pure.

   d. Any mixtures of the above.

   e. 1,1,1-Trichloroethane, Federal Specification O-T-620.

   Other solvents require approval of the procuring activity.

3. **Cleaning Procedures.** Procedures for cleaning shall be generated before solvent-cleaning is begun.

CHAPTER 4: CRIMP CONNECTIONS

3H400 GENERAL

1. **Tools and Equipment.** The tools and equipment shall produce crimps that meet the requirements of this document.

2. **Records.** The supplier shall develop and maintain records of tool calibration. Records shall be kept to identify and correlate the operator, the finished product, and the tools utilized. Comprehensive records shall be kept of the calibration of tooling as required herein.

3. **Shield** Terminations — Crimp Type. Shield crimp terminations shall meet the requirements of this document.

4. **Wire.** Crimping of solid wire is prohibited. Stranded wire shall be used.

5. **Uncalibrated Crimp Tools.** The use of uncalibrated or out-of-calibration crimp tools is prohibited.

3H401 TOOL AND EQUIPMENT CONTROL

1. **Tool Identification.** Each crimp tool shall be identified and marked. As a minimum the markings shall include the following:

   a. Serial number.

   b. Date of calibration.

   c. Date calibration expires.

2. **Full-Cycle Ratcheting.** Crimp tools shall contain a full-cycle ratcheting mechanism which shall prevent the indenters from releasing before the crimp cycle has been completed.

3. **Number of Indenters.** Each crimp tool shall have a minimum of four indenter blades (preferably double-indenter blades).

4. **Calibration Adjustments.** The calibration adjustments shall be accessible only when the tool is disassembled. These adjustments shall be made only by the manufacturer of the tool or by a calibration laboratory.

5. **Sealing of Adjustable Tools.** All adjustable crimp tools shall be calibrated, set, and sealed prior to their application.

3H402 CALIBRATION OF TOOLS

1. **Calibration Method.** The initial calibration and the recalibration of the crimp tools shall be in accordance with MIL-C-22520.

2. **Calibration Period.** Tools shall be recalibrated every 6 months unless a longer recalibration period is approved by the NASA procuring activity; however, the overall calibration period shall not exceed 12 months.

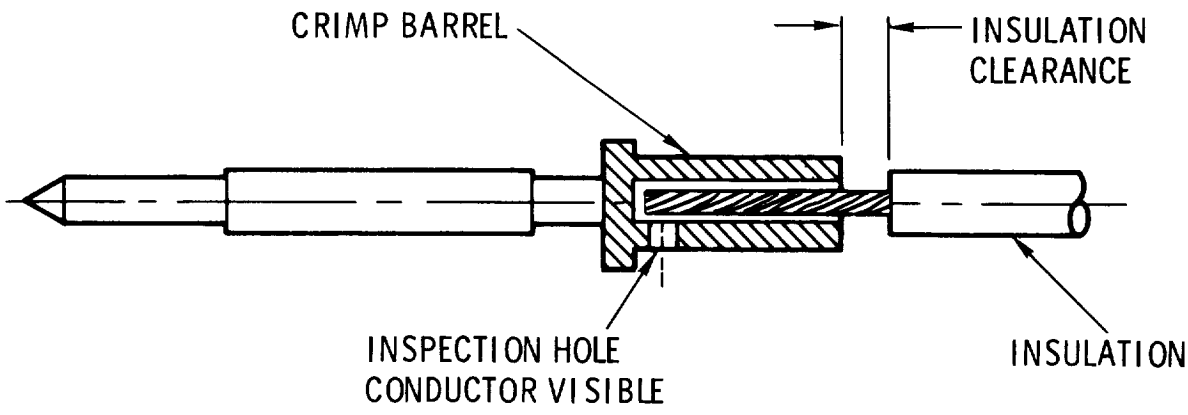
3H403 PREPARATION FOR CRIMPING

1. **Insulation Removal.** Stripping equipment used to remove conductor insulation shall be of the correct size and shall be in current adjustment and calibration.

2. **Conductor Insertion and Insulation Clearance** (see Figure 4-1). The conductor shall be visible in the inspection hole. Insulation clearance shall meet the following dimensions:

   a. .01 to .03 (.25 to .76 mm) for No. 20 AWG and smaller.

   b. .01 to .05 (.25 to 1.27 mm) for No. 18 AWG and larger.



CONTACT WITH TYPICAL CRIMP BARREL

FIGURE 4-1
CONDUCTOR INSERTION AND INSULATION CLEARANCE

3. **Damage to Insulation.** After the necessary insulation removal, the remaining conductor insulation shall not exhibit any damage such as nicks, cuts, crushing, or charring. Conductors with damaged insulation shall not be used. Slight discoloration from thermal stripping is acceptable.

4. **Damage to Conductors.** After removal of the conductor insulation, the conductor shall not be nicked, cut, scraped, or otherwise damaged. Burnishing of the wire is allowed providing the base material (copper) is not exposed. Conductors which have been reduced in cross-sectional area shall not be used. Damaged wires shall not be used.

5. **Wire Lay.** If the lay of wire strands has been disturbed, it shall be restored as nearly as possible to the original lay.

3H404 EXAMINATION OF CRIMP CONTACT

For manual crimping operations prior to wire insertion, the assembler shall examine the crimp contacts. Contacts that show the following conditions shall not be used.

1. Cracks in the plating or base metal.

2. Plating removal or flaking.

3. Out-of-roundness of the wire well entrance.

4. Exposed base metal.

3H405 SHIELDS TERMINATED BY CRIMP FERRULES

Shields terminated by two-piece, metal crimp ferrules shall meet the criteria given in Figure 4-2. The inner ferrule shall be sufficiently large so that any inward distortion caused by crimping will not affect the insulated wires it contains.

The grounding wire detachment force from the crimped sleeve shall meet the requirements of Table 4-1.

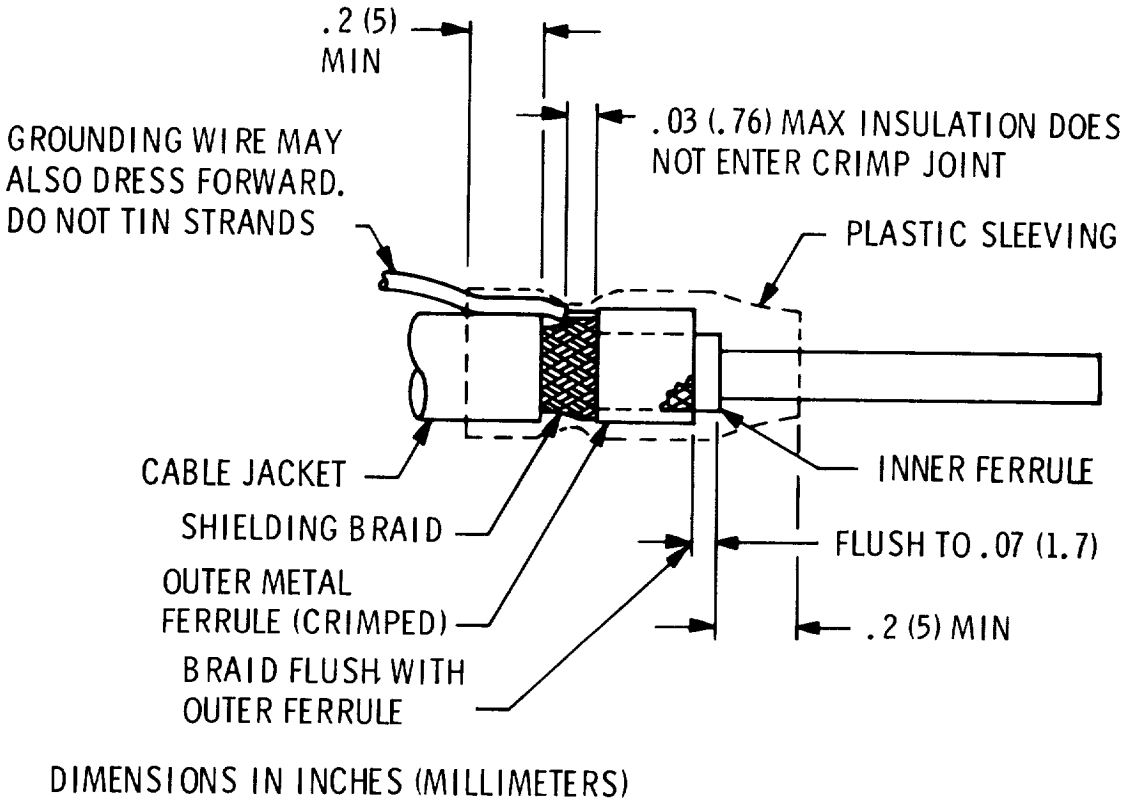


FIGURE 4-2
SHIELD TERMINATED BY CRIMPED FERRULES

TABLE 4-1
DETACHMENT FORCE

Grounding Lead Wire Size	Wire Breakage or Pullout, Minimum Pounds (Newtons)
AWG 24 Copper	8 (35.6)
Copper alloy 1/	14.4 (64.0)
AWG 22 Copper	12.8 (56.9)
Copper alloy 1/	22.2 (98.7)

1/ Copper alloy refers to high strength copper alloy.

3H406 PROCESS CONTROLS

1. **Examination of Crimp Tools.** Tools in current use and tools to be used shall be examined as follows:

   a. Nonadjustable tools. If the tool is broken or damaged, it shall be removed from service.

   b. Tools with a sealed setting and sealed locator or position. If the tool is broken or damaged, or if the seal is broken, the tool shall be removed from service.

   c. Records of examination shall be maintained for hand tools.

2. **Test Method.** The crimp contacts shall be placed in a tensile-testing device with appropriate fixtures, and sufficient force shall be applied to pull the wire out of the assembly or to break the wire or crimped item. The head travel speed of the tensile device shall be 1.0 ± .25 inch (25.4 ± 6.3 mm) per minute. The holding surfaces of the tensile device clamp may be serrated to provide sufficient gripping and holding ability.

3. **Test Interval.** The crimp tools and each contact-conductor combination to be used in a production run shall be tested at the start and at the end of each work shift or production run, whichever is shorter. Test results shall be recorded and maintained for each crimp tool and contact-conductor combination.

4. **Number of Test Samples.** A minimum of three test samples shall be prepared for each crimp tool and crimp-contact-conductor combination, at the intervals specified in 3H406-3.

5. **Examination of Test Samples.** Each individual test sample shall be inspected to the requirements of this document and the observations recorded and maintained.

6. **Required Crimp Strength.** The tensile strength of the crimp test sample connections shall be in accordance with Table 4-2. For those contact-conductor crimp connections not contained in Table 4-2, the tensile strength of the crimp connection shall be no less than 60 percent of the tensile strength of the wire.

TABLE 4-2
CRIMP TENSILE STRENGTH 2/

Wire Barrel Size	Conductor Size, AWG	Base Conductor Material 1/	Tensile Strength, Pounds (Newtons), Minimum
22M, 24	28	Copper alloy 3/	4.8 (21.3)
	28	Copper	3.1 (13.8)
	26	Copper alloy 3/	8.0 (35.6)
	26	Copper	5.2 (23.1)
	24	Copper alloy 3/	14.4 (64.0)
	24	Copper	8.0 (35.6)
* 22	26	Copper	3.0 (13.3)
	26	Copper alloy 3/	3.0 (13.3)
	24	Copper alloy 3/	5.0 (22.2)
	24	Copper	5.0 (22.2)
	22	Copper	8.0 (35.6)
	22	Copper alloy 3/	8.0 (35.6)
* 22D	28	Copper alloy 3/	3.0 (13.3)
	28	Copper	3.0 (13.3)
	26	Copper alloy 3/	5.0 (22.2)
	26	Copper	5.0 (22.2)
	24	Copper alloy 3/	8.0 (35.6)
	24	Copper	8.0 (35.6)
	22	Copper	12.0 (53.3)
	22	Copper alloy 3/	12.0 (53.3)
20	24	Copper alloy 3/	14.4 (64.0)
	24	Copper	8.0 (35.6)
	22	Copper	12.8 (56.9)
	20	Copper	20.6 (91.6)
	22	Copper alloy	22.2 (98.7)
16	20	Copper	20.6 (91.6)
	18	Copper	32.0 (142.3)
	16	Copper	41.2 (183.3)
12	14	Copper	65.1 (289.5)
	12	Copper	103.2 (459.0)
10	10	Copper	159.0 (707.2)
8	8	Copper	288.0 (1281.0)

1/ Refer to applicable wire specifications for the determination of conductor base material.

2/ For contact-conductor combinations not listed in the table, the requirements of 3H406-6 shall apply.

3/ Copper alloy refers to high strength copper alloy.

3H407 ALLOWABLE CONTACT-CONDUCTOR COMBINATIONS AND CALIBRATION OF ADJUSTABLE TOOLS

1. **Contact-Conductor Combinations.** The contact-conductor combinations shall be in accordance with Table 4-3.

TABLE 4-3
MANUFACTURERS RECOMMENDED
CONTACT-CONDUCTOR COMBINATIONS 1/

Contact Wire Barrel Size	Conductor Size, AWG
22M, 24	24, 26, 28
22	22, 24, 26
22D	22, 24, 26, 28
20	20, 22, 24
16	16, 18, 20
12	12, 14
10	10
8	8

1/ For contact-conductor combinations not listed in the table, the requirements of 3H406-6 shall apply.

2. **Determination of Crimp Tool Settings.** The determination of optimum crimp tool settings shall be made during calibration and recalibration of the crimp tool. The determination of optimum settings on adjustable crimp tools shall be as follows:

At least three test specimens shall be pulled at each indenter setting that has produced crimp joints meeting the tensile strength requirements of paragraph 3H406-6. After pulling, the test specimens shall be examined under the microscope to determine the method of conductor failure. Crimp joint tensile failures will fall into one of the

categories shown in Figure 4-3. The crimp tool setting which produces the maximum number of fray breaks and breaks outside the contact shall be used for assembly(see Note). If multiple settings provide identical tensile strengths for a crimp joint, the setting selected shall be the one that provides more wire breaks than wire pull-outs. These settings shall be recorded and identified.

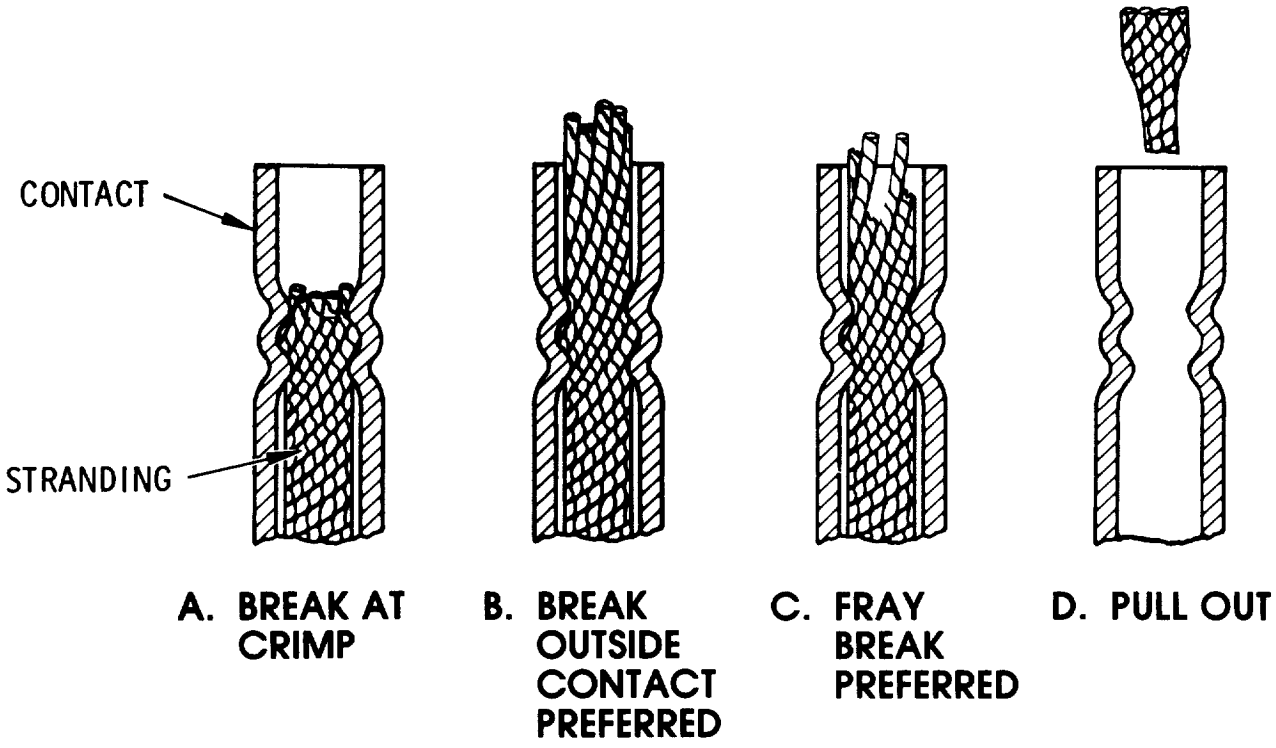


FIGURE 4-3
CRIMP JOINT TENSILE FAILURE CATEGORIES

The supplier shall assure that all adjustable crimping tools have been calibrated, set and sealed for each application prior to their use. The quality organization shall verify and seal each crimp tool after tool is calibrated, and verify tool implementation for each application just prior to tool use.

NOTE

Breaks at the entrance of the contact wire barrel, caused by conductor cutting because the contact is not held squarely in the tester jaws, shall not be identified with preferred breaks.

3H408 QUALITY ASSURANCE PROVISIONS

1. **General.** The supplier shall assure that all the requirements for crimp connections in this document are met.

2. **Personnel Certification.** The supplier shall assure that all personnel fabricating or inspecting crimp connections to the requirements of this document are certified to the requirements of this chapter and paragraph 3H201.

3. **Work Areas and Facilities.** Work areas and facilities shall meet the requirements of Chapter 3.

4. Tools

   a. Calibration records. The supplier shall assure that the calibration records of all equipment and tools used in the manufacturing of crimp connections are maintained for the time period specified by contract.

   b. Product verification records. The supplier shall assure that the records documenting product materials and assembly are kept as specified by contract. As a minimum these records shall contain the following:

      (1) Material lot numbers.

      (2) Suppliers of material.

      (3) Identification of tools used.

      (4) Names of the manufacturing personnel performing the operations.

   c. Records on crimp tools. The supplier shall assure that records are kept on the maintenance and repair of the crimp tools for the time period specified by contract.

5. **Process Verification Records.** The supplier shall assure that the process verification records are kept and maintained. These records shall include as a minimum the individual test results of the pull tests, the condition of the test sample, the tool identification number, the contact-conductor combination, and the date of testing.

6. **Visual Inspection**

   a. Inspection. All crimp connections shall be inspected to the requirements of this document.

   b. Magnification. Inspection shall be aided by magnification of 4- to 10-power as appropriate to the size of the connections. Additional magnification shall be used as necessary to resolve suspected anomalies or defects.

7. **Acceptance Criteria.** Acceptance criteria shall be as follows:

   a. Contact deformed only by tool indentations.

   b. Crimp indents properly located in the correct area of the contact.

   c. Wire strands visible in inspection hole of barrel.

   d. Shield termination free of loose strands or projecting strands.

   e. Wire insulation and jacket free of punctures, cuts, nicks, and deformation.

   f. Metal ferrules tightly and symmetrically crimped.

   g. Insulation sleeving uniformly shrunk, providing proper covering and securing the wires into place.

   h. Wire strands not broken, nicked, or cut. Burnishing is permissible provided the base material is not exposed.

   i. Wire insulation not nicked, cut, crushed, or charred. Slight discoloration from thermal stripping is acceptable.

   j. The clearance between the wire insulation termination and the crimp contact barrel is between .01 to .03 inch for wire sizes AWG 20 and smaller, and .01 to .05 inch for wire sizes AWG 18 and larger.

   k. Shield strands shall be clean, with nicks not exceeding 10 percent of total number of strands.

8. **Rejection Criteria.** Rejection criteria shall be as follows:

   a. Loose or projecting strands on shield terminations.

   b. Wire insulation with cuts, punctures, or crushing.

c. Metal ferrules crimped with improper alignment.

d. Cracked, charred, or split insulation sleeving.

e. Excessive number of nicked braid strands.

f. Improper sleeving coverage.

g. Cracks in crimp barrel.

h. Birdcaging of conductor.

i. Wire strands not visible in inspection hole.

j. Peeling or flaking of plating on contact.

k. Damaged or deformed crimp contact.

l. Damaged insulation in excess of slight discoloration from thermal stripping operation.

m. Damaged strands. Burnishing is permissible provided the base material is not exposed.

n. Reduction of conductor cross-sectional area.

o. Crimp indents not located in the correct area on the contact.

p. Tarnished, corroded, or contaminated crimp contact.

q. Improper insulation clearance.

r. Insulation whiskers that extend into the crimp barrel.

CHAPTER 5: SOLDERLESS WRAPPED ELECTRICAL CONNECTIONS

3H500 GENERAL

1. **Description.** Solderless wrapped connections shall be made by wrapping a specified number of turns of wire under tension around a post with sharp corners. The sharp corners of the wrappost shall produce high pressure points resulting in indentations in the wire, or both the wire and wrappost, sufficient to meet the requirements of the strip test (see paragraph 3H506-3a). The resulting gas-tight, high-pressure points shall provide electrical continuity and mechanical stability. Wrappost connections covered by this chapter shall be Class A. (See Appendix A.)

   Class B wrapped connections shall be prohibited.

2. **Records.** The supplier shall develop and maintain records of tool calibration and verification.

3H501 MATERIALS

1. **Wire.** Wire for solderless wrapped electrical connections shall conform to MIL-W-81822 or other approved specifications. Insulation type and conductor plating shall be approved by the procuring activity. The wire selected shall not have the insulation bonded to the conductor.

2. **Wrappost**

   a. Wrappost geometry. The wrappost shall be in accordance with Figures 5-1 and 5-2, unless otherwise approved by the procuring activity.

   b. Material. Wrappost material shall be as specified in the applicable specification.

   c. Tip configuration. The tip of the wrappost shall terminate in a radius or bevel to facilitate insertion into the wrapping tool. If the tip of the wrappost terminates in a bevel, the apex of the bevel shall be flat, not to exceed .010 inch (.24 mm) square on a .025-inch (.64 mm) square post, and .015 by .06 inch (.76 by 1.52 mm) on a .45-inch (1.14 mm) square post or a .06 by .03 inch (1.52 by .76 mm) rectangular post.

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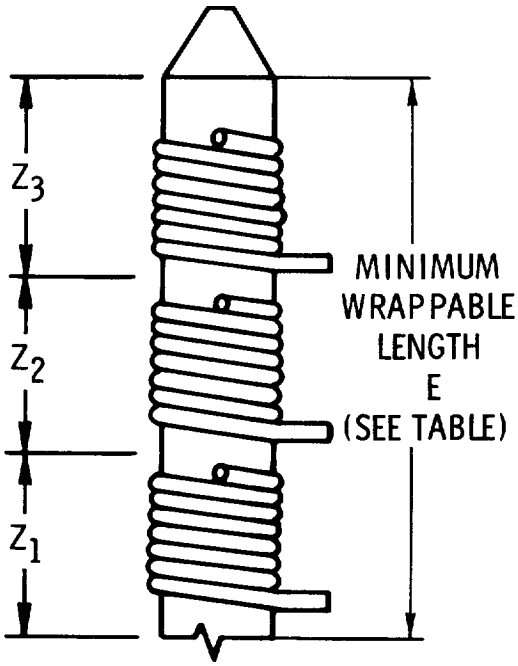
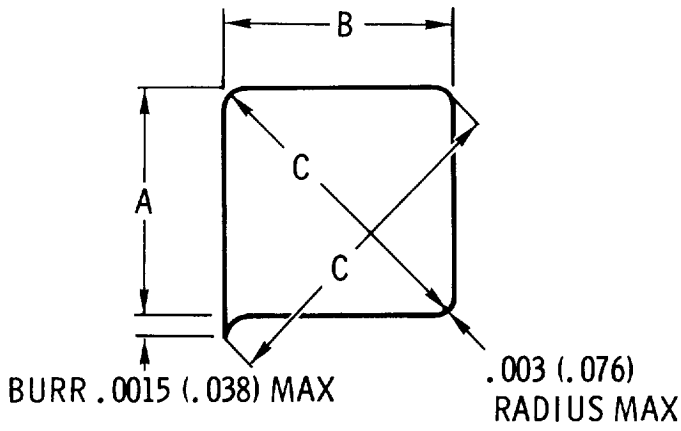


MINIMUM WRAPPABLE LENGTH E

Number of Wrapped Connections	Wire Gage						
	30	28	26	24	22	20	18
1	.185 (4.70)	.219 (5.56)	.226 (5.74)	.258 (6.55)	.303 (7.70)	.327 (8.31)	.391 (9.93)
2	.320 (8.13)	.388 (9.86)	.402 (10.21)	.466 (11.83)	.556 (14.12)	.604 (15.34)	.732 (18.59)
3	.455 (11.56)	.557 (14.15)	.578 (14.68)	.674 (17.12)	.809 (20.55)	.881 (22.38)	1.073 (27.25)

DIMENSIONS IN INCHES (MILLIMETERS)

FIGURE 5-1
MINIMUM WRAPPABLE LENGTH



WRAPPOST GEOMETRY

A	B	C	Straightness mm/mm or in/in
.025 (.64) nom .022 (.56) min	.025 (.64) nom .022 (.56) min	.0355 (.90) max .0325 (.08) min	.005
.045 (1.14) nom .042 (1.07) min	.045 (1.14) nom .042 (1.07) min	.066 (1.68) max .059 (1.50) min	.005
.030 (.76) nom .027 (.69) min	.060 (1.52) nom .057 (1.45) min	.070 (1.79) max .063 (1.60) min	.005

DIMENSIONS IN INCHES (MILLIMETERS).

FIGURE 5-2
TERMINAL DIMENSIONS

d. Plating. Wrapposts shall be gold plated in accordance with MIL-G-45204, Class 1, over nickel in accordance with QQ-N-290. The thickness of the nickel plating shall be a minimum of 30 microinches (.76 micrometers).

CAUTION!

SILVER UNDERPLATING SHALL NOT BE USED

e. Wrapposts shall be sufficiently durable to withstand being unwrapped and rewrapped 10 times and still meet requirements of 3H506.3.

3H502 TOOLS

1. **Wire Wrapping Equipment.** The supplier shall select and use wire wrapping equipment and tools that meet the following requirements:

   a. Wire wrapping tools shall not nick, ring, gouge, or scrape conductors or damage the wrappost in any way.

   b. Wire wrapping tools or machines shall be of the correct size and shall be maintained within calibration.

   c. Hand powered or battery-powered wrapping tools shall not be used.

2. **Wrap Stripping Tools.** The supplier shall select wrap stripping tools and equipment that do not nick, ring, gouge, scrape, or damage the wrappost in any way.

3. **Unwrapping Tools.** The unwrapping tools shall be capable of unwrapping the wire from the post either with a counterclockwise or clockwise movement without damaging the wirewrap post.

4. **Nonconforming Tools.** Nonconforming hand tools shall be removed from the production areas. All other nonconforming equipment shall be shut down and properly identified for discontinued service.

3H503 CALIBRATION OF TOOLS

1. **Wrapping Tools.** All wrapping tools shall be calibrated in accordance with Table 5-1.

TABLE 5-1
TOOL CALIBRATION

Requirement	Requirement Paragraph	Number of Test Specimens
Stripping force	3H506-3a	24
Conductor brittleness	3H506-3c	24
Workmanship	3H507-7 3H507-8	24

2. **Frequency.** Tools, including bit and sleeve, shall be calibrated prior to production use and at every 12-month interval thereafter or whenever the tool is repaired.

3. **Strip Force.** The strip force indicator shall be calibrated every 6 months unless data indicate that the calibration period may be extended; however, the indicator shall be calibrated at least once every 12 months.

3H504 PREPARATION FOR WIRE WRAPPING

1. **Insulation Removal.** Insulation shall be removed by manual or automatic tools. Stripping shall not expose base metal. Insulation removal shall conform to the criteria listed in 2 and 3.

2. **Damage to Insulation.** After the necessary insulation removal, the remaining conductor insulation shall not exhibit any damage such as nicks, cuts, crushing, or charring. Conductors with damaged insulation shall not be used. Slight discoloration from thermal stripping is acceptable.

3. **Damage to Conductors.** After removal of the conductor insulation the conductor shall not be nicked, cut, scraped, or otherwise damaged. Burnishing of the wire is allowed providing the base material (copper) is not exposed. Conductors which have been reduced in cross-sectional area shall not be used. Damaged wires shall not be used.

4. **Wrapping Tool Preparation and Evaluation.** Solderless wrapped connections shall be made with either automatic or handheld power tools in calibration and capable of wrapping connections which conform to all requirements of this Handbook.

5. **Wrappost Preparation and Examination.** Prior to wire wrapping, the wrappost shall be examined for the following:

   a. Wrappost alignment. The alignment or orientation shall be as specified in the drawing.

   b. Condition of post. The wrappost shall exhibit no cracking, flaking of plating, or other damage.

6. **Test Specimen Preparation.** The test specimens shall be prepared to the requirements of this document using the tools, materials, and processes to be used during production.

3H505 WRAPPING CRITERIA

1. **Number of Turns on Wrappost.** Table 5-2 specifies the number of turns of wire to be used. The maximum space between adjacent turns, including the first and last half turns, shall not exceed one half the nominal uninsulated diameter of the wire; there shall be no overlap of turns. The endtail shall not extend beyond the outside diameter of the wire on the wrappost by more than the diameter of the stripped wire.

TABLE 5-2
NUMBER OF WIRE TURNS ON WRAPPOST

AWG Wire Size	Wire Diameter		Minimum Number of Turns
	Inches	(mm)	Class A
30 1/	.010	(.25)	7 stripped turns plus 1/2-turn insulated
28 1/	.0126	(.329)	7 stripped turns plus 1/2-turn insulated
26	.0159	(.404)	6 stripped turns plus 1/2-turn insulated
24	.0201	(.510)	5 stripped turns plus 1/2-turn insulated
22 1/	.0253	(.643)	5 stripped turns plus 1/2-turn insulated
20 1/	.0320	(.813)	4 stripped turns plus 1/2-turn insulated
18 1/	.0403	(1.024)	4 stripped turns plus 1/2-turn insulated

1/ Wire sizes AWG 28 and 30 are not recommended for use on wrapposts with cross sections of .045 by .045 inch (1.14 by 1.14 mm) or .030 by .060 inch (.76 by 1.52 mm). Wire sizes AWG 18, 20, and 22 are not recommended for use on wrapposts with a cross section of .025 by .025 inch (.64 by .64 mm).

2. **Usage of Wrap Levels.** Wrap position. Wrapping positions on a three-level wrappost are shown in Figure 5-3. Z-levels are shown for reference. Wraps that extend above the Z_3 level (on the beveled portion of the post top) shall be removed and replaced. Lower wrappers may extend into the Z_3 level if it is open and not reserved for future wiring. The lowest wrapper may be at the Z_2 level when wire dressing requires it. Each termination level and wire routing shall be identified on the engineering documentation.

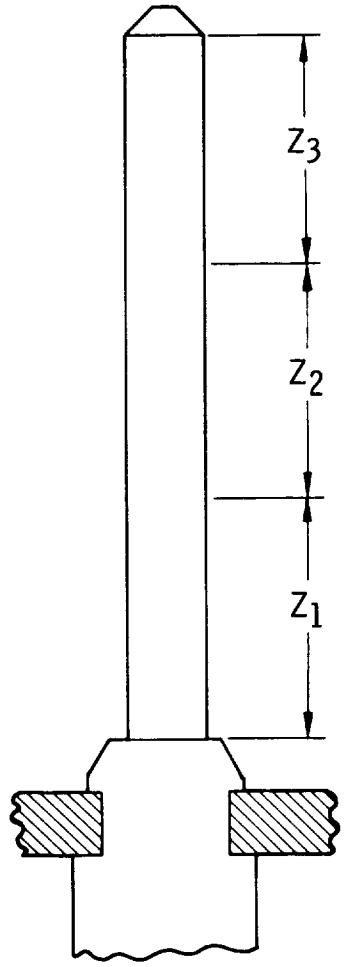


FIGURE 5-3
WRAPPER POSITIONS, THREE-LEVEL POST

3. **Wire Routing.** Wire routing around and between wrapposts shall be such that wires do not press against wrappost corners with sufficient force to cut the insulation. Wire with insulation which has been cut shall be removed and replaced.

4. **Reattachment and Rerouting.** Defective connections other than those requiring pigtail-tightening shall be removed by the unwrapping tool and the wire discarded. High wraps shall be removed and replaced rather than being tamped down on the wrappost. When replacement connections are made, the wire routing shall follow the original route as nearly as possible.

   Wires may be rerouted with or without detachment to correct a tight wire condition or relieve a wire density problem.

5. **Wire Position.** Before wrapping, the wire shall be positioned radially so that subsequent routing of the wire does not unwrap the connection.

3H506 PROCESS CONTROL

1. **Process Certification.** The capability of the wrapping tools to provide acceptable, solderless wrapped electrical connections shall be established for each combination of wrappost (based on cross sectional geometry), wire gage, conductor material, and wrapping bit and sleeve configuration by preparing 24 sample connections and testing and inspecting them to the requirements of Table 5-3.

   Certifications shall be performed initially upon receipt of new tools and when production wraps fail to meet criteria specified in paragraph 3H506-2.

2. **In-Process Certification Controls and Test.** Following the initial certification of a process, samples shall be prepared, tested and inspected in accordance with the requirements of Table 5-4 at the time intervals specified.

3. **Test Requirements**

   a. Strip force. A completed, solderless wrapped connection, with the minimum number of turns listed in Table 5-2, shall be capable of meeting the minimum strip force specified in Table 5-5. The minimum strip force shall be the measurement taken immediately after the strip force has been applied and before the wrapped conductor has been moved one wire diameter from its original position.

TABLE 5-3
INSPECTION OF SAMPLES FOR PROCESS CERTIFICATION

Number of Samples to be Tested	Requirements
6	Strip force in accordance with paragraph 3H506-3a .
6	Unwrap in accordance with paragraph 3H506-3c .
6	Gas-tightness in accordance with paragraph 3H506-3b .
6	Wrapper resistance in accordance with paragraph 3H506-3d .

TABLE 5-4
INSPECTION OF SAMPLES FOR IN-PROCESS CERTIFICATION

Number of Samples to be Tested	Requirements	Inspection Interval
6	Strip force in accordance with paragraph 3H506-3a .	Daily
6	Unwrap in accordance with paragraph 3H506-3c .	Daily

TABLE 5-5
STRIP-FORCE LIMITS

AWG Wire Size	Conductor Diameter in (mm)	Minimum Strip Force Pounds (Newtons)	
		.025 in (.64 mm) square 1/	.045 in (1.14 mm) square or .03 by .06 in (.76 by 1.52 mm) 1/
30	.010 (.25)	2.0 (8.9)	—
28	.0126 (.329)	3.0 (13.3)	—
26	.0159 (.404)	4.0 (17.8)	6.0 (26.7)
24	.0201 (.510)	5.0 (22.2)	7.0 (31.1)
22	.0253 (.643)	—	8.0 (35.6)
20	.0320 (.813)	—	9.0 (40.0)
18	.0403 (1.024)	—	15.0 (66.7)

1/ Wrappost cross section in inches (mm).

The samples shall be tested using the test fixture illustrated in Figure 5-4. Records shall be kept of all test results identified with the individual test samples. If any individual test sample fails the minimum applicable test requirements, it shall be cause for rejection of all wraps made after the last successful test sequence, and the wire wrap tool shall be submitted to the certification process of 3H506-1 to determine cause of process failure. The strip force test fixture shall meet the following requirements:

(1) The stripping jaw shall engage at right angles to axis of the wrappost.

(2) When the wrappost and stripping fixture are properly aligned, the clearance shall be such that there is no binding or wedging between jaw and wrappost. The clearance between the wrappost and test fixture jaws shall not exceed 70 percent of the wire diameter.

(3) Both sides of the stripping jaw shall be in the same plane, creating a flat surface contact with the wire on either side of the wrappost.

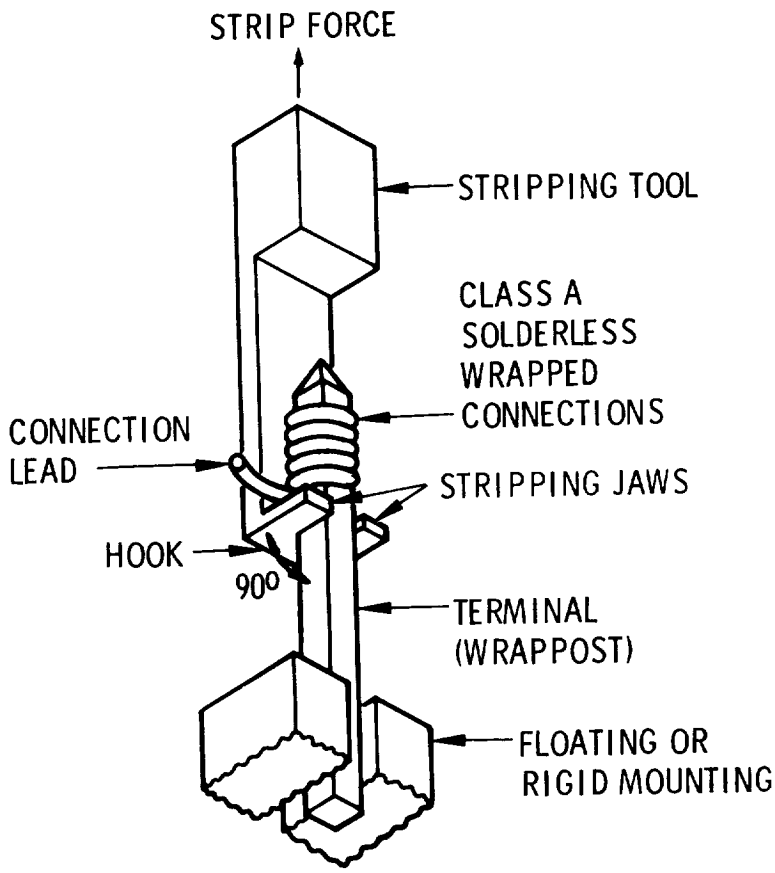


FIGURE 5-4
STRIP FORCE TEST FIXTURE

(4) On a rectangular post, the jaws of the hook shall engage along the major cross sectional dimension of the terminal. The maximum total clearance between jaw and terminal shall not exceed 0.7 times the diameter of the wire. The minimum clearance, when the terminal and stripping tool are properly aligned, shall be such that there is no binding between jaw and terminal.

(5) The equipment shall be capable of applying stripping force at a uniform rate of 1 to 10 inches (25 to 254 mm) per minute.

b. Gas-tightness. Seventy-five percent of the corners in contact with uninsulated wire, except for the first and last turns, shall be gas tight when tested as follows:

(1) Darken the assembly with ammonium sulphide gas after the wrappost has been exposed to aqua regia fumes in accordance with the following:

(a) The wrappost shall be suspended above the solution in a 16 by 150 mm rubber-stoppered test tube containing approximately 1 to 2 milliliters (ml) of aqua regia solution (3 parts of concentrated hydrochloric acid to 1 part of concentrated nitric acid). The solution shall not touch the wrappost assemblies. The wrappost assemblies shall be exposed to the aqua regia fumes for at least 10 minutes.

CAUTION!

AQUA REGIA IS EXTREMELY CORROSIVE AND TOXIC. PROTECTIVE CLOTHING AND PROPER VENTILATION ARE NECESSARY WHEN USING THIS REAGENT.

(b) The chemically attacked wrappost shall be suspended above the solution in another 16 by 150 mm test tube containing approximately 1 ml of concentrated ammonium sulphide solution. The test tube shall be stoppered, and the specimen shall be exposed to the ammonium sulphide fumes until it turns dark. Copper and gold sulphide color will be developed on all areas exposed to the vapor.

(c) The wrappost shall be dried. The connections shall be unwrapped with a tool which does not scratch the post. The gastight areas will appear in bright, sharp contrast to the discolored areas.

(2) Records shall be kept of all test results identified with individual test samples. If any individual test sample fails, it shall be cause for machine recalibration and process recertification.

c. Unwrap test. Wire on the wrappost shall be capable of being unwrapped without conductor breakage.

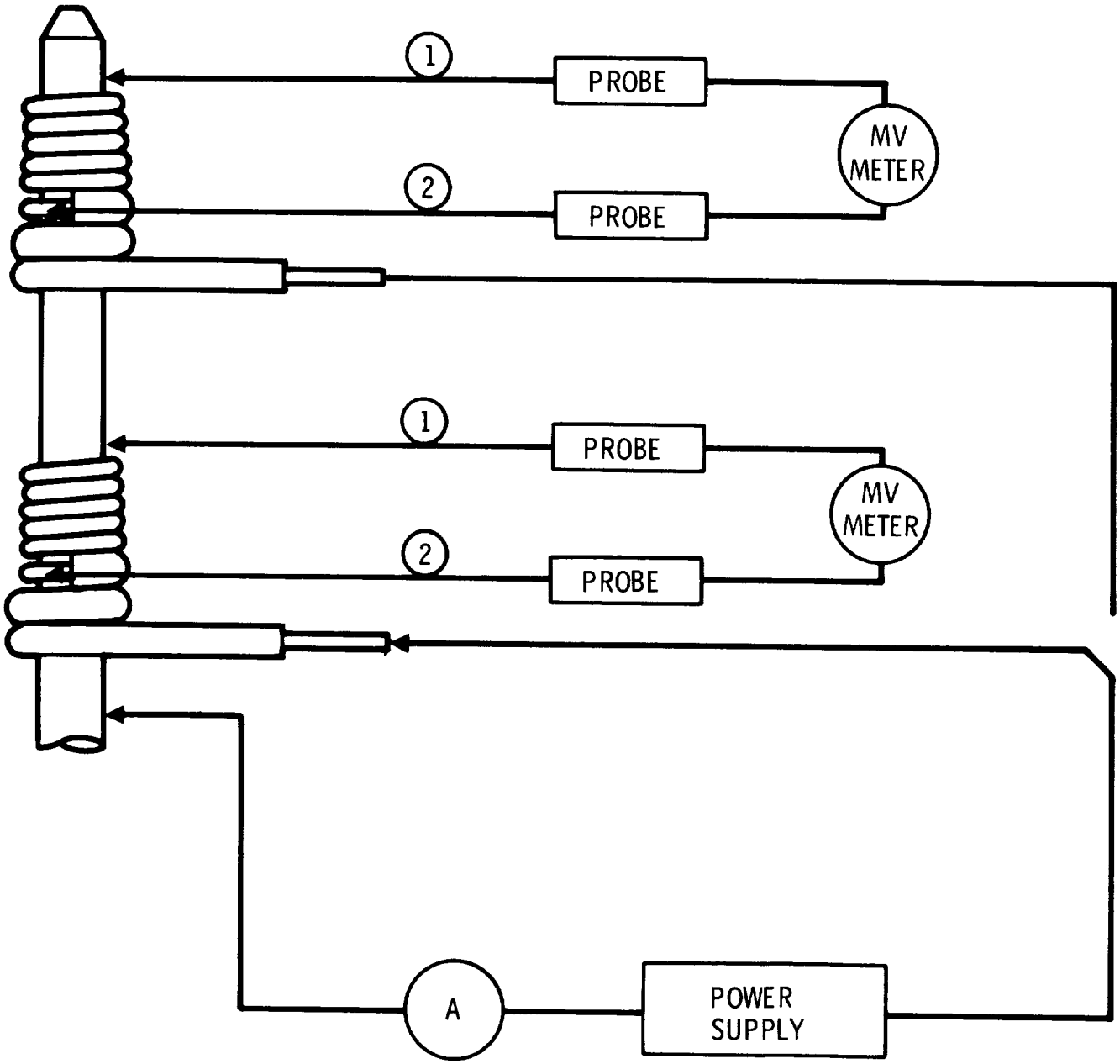
(1) Unwrap test (conductor brittleness). Place the unwrapping tool over the terminal post and engage its leading edge between the wrap end and the next wrap turn. Rotate the unwrapping tool until all the wire has been

transferred onto the tool. Remove the tool with the loose, helical coil from the terminal post. Holding the insulated portion of the wire firmly, rotate the tool and unwind the wire. The unwrapped wire will not be straight; waves and permanent deformation are permissible.

(2) Records shall be kept of all test results identified with individual test samples. If any individual test sample fails the minimum applicable test requirements, it shall be cause for rejection of all wraps made after the last successful test sequence.

d. Wrapper resistance. When measured as illustrated in Figure 5-5, at the current specified in Table 5-6, the voltage drop across the wrapped connection shall not exceed 4 millivolts.

Records shall be kept of all test results identified with individual test samples. If any individual test sample fails, it shall be cause for machine recalibration and process recertification.



NOTES:

(1.) THIS PROBE SHALL NOT TOUCH THE WIRE.

(2.) THIS PROBE SHALL BE PLACED ON THE FIRST TURN OF UNINSULATED WIRE.

FIGURE 5-5
WRAPPER RESISTANCE TEST

TABLE 5-6
WRAPPER RESISTANCE

AWG Wire Size	Conductor Diameter		Current to be Used to Determine Wrapper Resistance (Amperes)
	Inches	(mm)	
30	.010	(.25)	1.0
28	.0126	(.329)	2.0
26	.0159	(.404)	2.4
24	.0201	(.510)	2.4
22	.0253	(.643)	2.4
20	.0320	(.813)	7.5
18	.0403	(1.024)	7.5

3H507 QUALITY ASSURANCE PROVISIONS

1. **General.** The quality assurance activity of the supplier shall assure that the requirements of this document are met.

2. **Personnel Certification.** All personnel inspecting or fabricating wire wraps to the requirements of this document shall be certified to the requirements of this chapter.

3. **Work Areas and Facilities.** Work areas and facilities shall meet the requirements of Chapter 3.

4. **In-Process Control Tests.** At every 24-hour interval, the tests of 3H506-2 shall be performed.

5. **Test Records and Review.** The supplier shall assure that all records of all tests performed in this process and their respective results are kept and maintained for the period specified by contract. These records shall be kept in an orderly fashion and shall be available for inspection upon request from the NASA Installation or its authorized representative.

6. **Tool Records**

   a. Calibration records. The supplier shall assure that the calibration records on all equipment used in the manufacturing of wire wrap electrical connections are maintained for the period specified by contract.

b. Product verification records. The supplier shall assure that the records documenting the assembly of and materials used in the product are kept for the period specified by contract. As a minimum these records shall contain the following:

(1) Material lot number.

(2) Supplier.

(3) Equipment used.

(4) Identification of manufacturing and inspection personnel performing the operations.

7. **Visual Inspection Criteria**

a. Inspection. All wire wrap connections and the routing of the wires shall be inspected to the requirements of this document.

b. Magnification. Inspection shall be aided by magnification appropriate to the size of connections, i.e., between 3- and 10-power. Additional magnification shall be used as necessary to resolve suspected anomalies or defects.

8. **Acceptance Criteria.** Acceptance criteria shall be as follows:

a. The number of turns shall conform to Table 5-2.

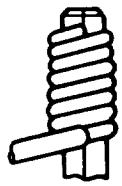
b. Connections shall be clean and free of foreign material.

c. None of the conditions described in 3H507.9 below are present.

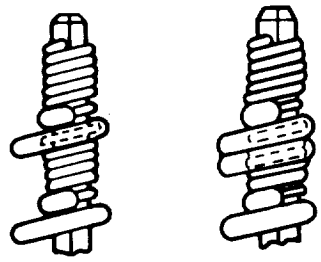
9. **Rejection Criteria.** Rejection criteria shall be as follows:

a. No insulation or insufficient insulation in contact with wrappost (see Figure 5-6A).

b. Improper wrapper spacing and overlapped wrappers. There shall be no overlapping within the minimum specified number of turns of uninsulated wire except that the first turn of insulated wire in a modified, solderless wrapped connection may overlap the last turn of uninsulated wire in a connection below it on the same terminal (see Figure 5-6B). Wire shall not be wrapped too high on the post (see Figure 5-6C). Insulation must make a contact bite within a minimum of three corners.



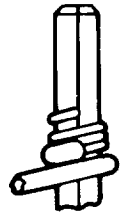
A. INSUFFICIENT INSULATION WRAP FOR CLASS A



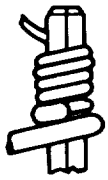
ACCEPTABLE REJECTION

B. OVERLAP CRITERIA

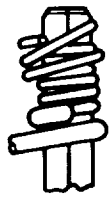
C. IMPROPER POSITIONING



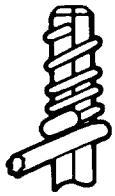
D. INSUFFICIENT TURNS



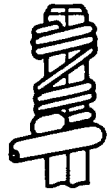
E. END TAIL



F. OVERWRAP



G. SPIRAL WRAP



H. OPEN WRAP

FIGURE 5-6
REJECTION CRITERIA

c. Insufficient number of wrapper turns to meet requirements of Table 5-2 (see Figure 5-6D).

d. End tail does not conform to the requirements of paragraph 3H505-1 (see Figure 5-6E).

e. Overlapping wrapper turns within a wrapper level (see Figure 5-6F).

f. Space between adjacent wrapper turns exceeds one-half the diameter of the uninsulated conductors (see Figures 5-6G and 5-6H). Excluding the first and last turns, the sum of all gaps shall not exceed one wire diameter.

g. Wire routed in a manner which will tend to unwrap the wire on the wrappost.

h. Wrappost exhibits improper alignment or orientation.

i. Wrappost exhibits cracking, flaking of plating or other damage.

j. Wire wraps have been moved on the wrappost by means other than removal and replacement.

APPENDIX A
DEFINITIONS

The following definitions apply to Crimp and Wire Wrap Fabrication.

Birdcaging. The radial expansion of individual strands in a stranded conductor (bowing outward) that can occur in the exposed portion of the conductor between the insulation strip and termination point.

Certification. The act of delegated authority in verifying and documenting that personnel have completed the required training, have demonstrated the specific proficiency, and have met other specified requirements.

Class A and Class B Solderless Wrapped Electrical Connections. See Solderless Wrapped Electrical Connections.

Conductor. A lead or wire, solid or stranded, serving as an electrical connection between terminals.

Gas-Tight. The mechanical and physical integrity of two mating metals so that gas, vapors, and/or impurities are excluded.

Interconnection. A process or system permitting the joining of discrete wire electrical connections. Also, the routing and terminating of discrete wires to form point-to-point electrical connections by use of special machines or tools.

Part. One piece or two or more pieces joined together which are not normally subject to disassembly without destruction of designed use. Synonymous with detail part and component part (for example, resistor, capacitor, valve, relay).

Repair. Operations performed on a nonconforming article to place it in usable condition. Repair is distinguished from rework in that alternate processes rather than reprocessing are employed.

Rework. The reprocessing of an article or material that will make it conform to a drawing, specification, or contract.

Solderless Wrapped Electrical Connections. The terminology and makeup of this type of connection on one type of wrappost configuration are illustrated in Figure A-1.

1. **Class A, Solderless Wrapped Electrical Connection (Preferred Method).** This connection consists of a helix of continuous, solid, uninsulated wire tightly wrapped around the wrappost of a solderless wrapped contact to produce a mechanically and electrically stable connection. The number of turns required will depend on the gage of wire used.

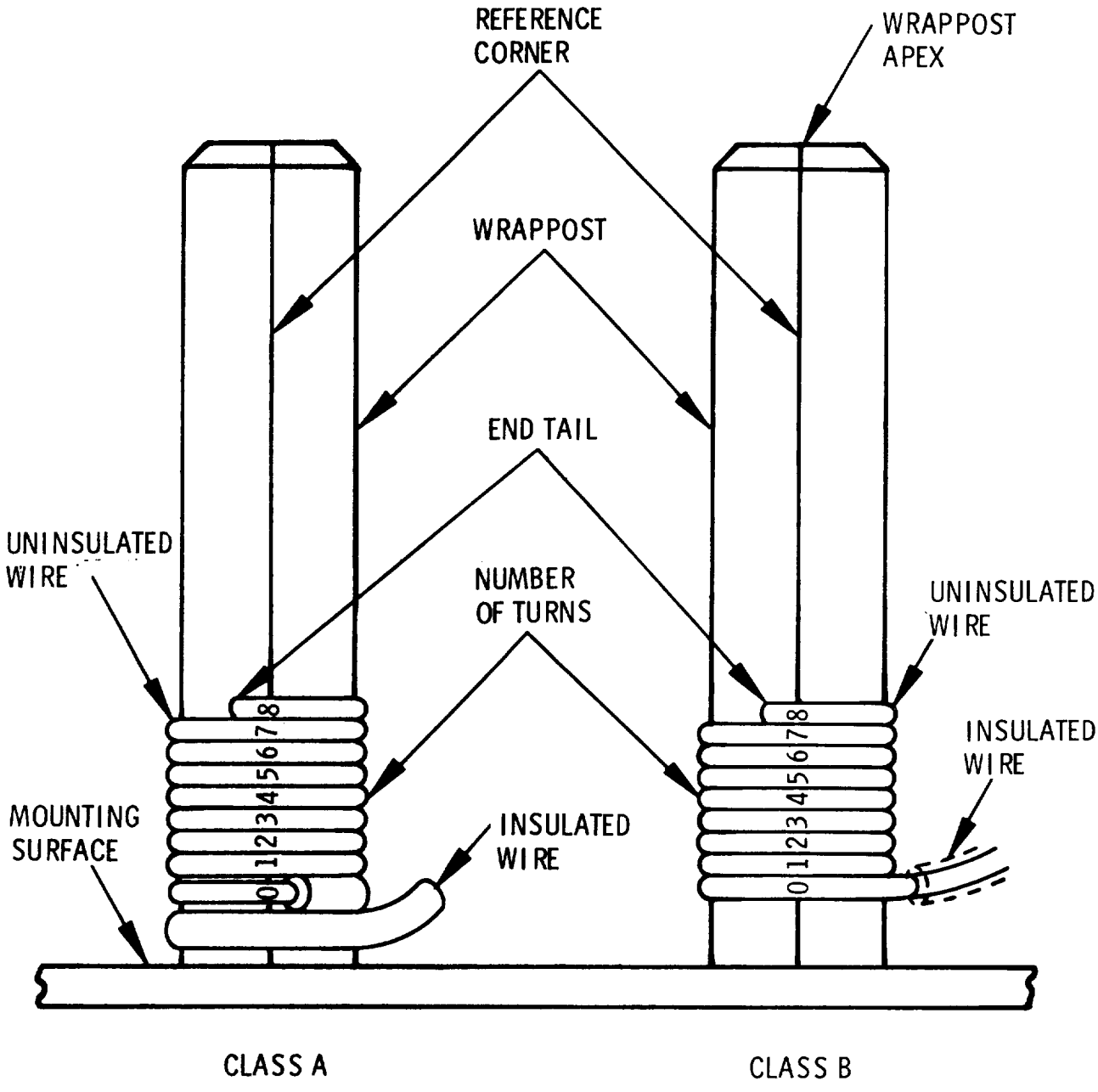


FIGURE A-1
SOLDERLESS WRAPPED CONNECTIONS ON A SQUARE WRAPPOST

In addition to the length of uninsulated wire wrapped around the wrappost, an additional minimum half turn of insulated wire shall be wrapped around the wrappost to help ensure better vibration characteristics. To accomplish a half turn, the wire must be in contact with at least three corners of the wrappost.

2. **Class B, Conventional Solderless Wrapped Electrical Connection.** This connection is the same as the Class A connection except that the additional half turn of insulated wire is not required.

3. **End Tail.** An end tail is the end of the last turn of wire of a solderless wrapped electrical connection which may extend in a tangential direction instead of resting against the wrappost.

4. **A Turn of Wire.** A turn of wire shall consist of one complete single helical ring of wire wrapped 360° around the wrappost. For the purpose of counting turns, the number of times the wrapped wire passes and intercepts the reference edge of the wrappost after the first intercept of uninsulated wire and wrappost shall constitute the number of turns of uninsulated wire in the connection.

5. **Gas-Tight Area.** The gas-tight area is that contact area between the wrappost and wire which due to the quality of the wrap excludes gas fumes.

6. **Reference Corner.** The corner at which the first turn of uninsulated wire intercepts is the reference corner.

APPENDIX B
ACCEPTABLE AND UNACCEPTABLE CRIMP AND WIRE WRAP ELECTRICAL CONNECTIONS, CRIMPS, AND WIRE PREPARATION

CRIMPS -- INSULATION CLEARANCE

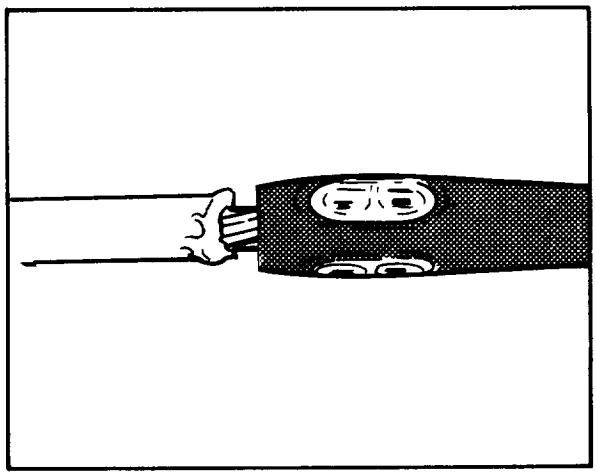


FIGURE B-1

MINIMUM CONDUCTOR EXPOSURE

Insulation terminates 0.010 in. minimum from contact crimp barrel.

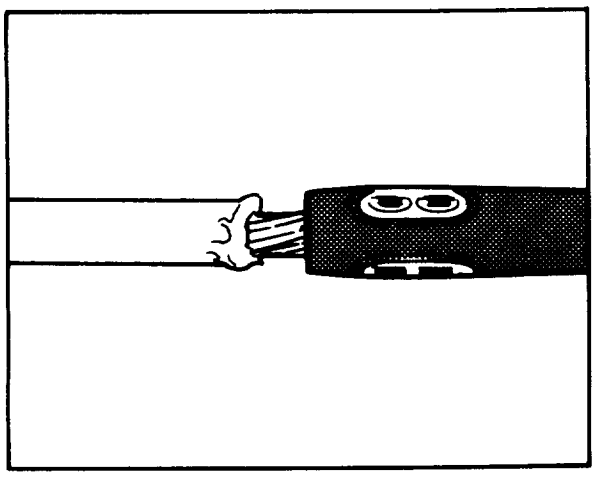


FIGURE B-2

MAXIMUM CONDUCTOR EXPOSURE

Amount of exposed bare wire between the insulation and the contact crimp barrel does not exceed 0.03 inch maximum for No. 20 AWG wire and smaller, and 0.05 inch maximum for No. 18 AWG wire and larger.

ACCEPTABLE AND UNACCEPTABLE CRIMPS

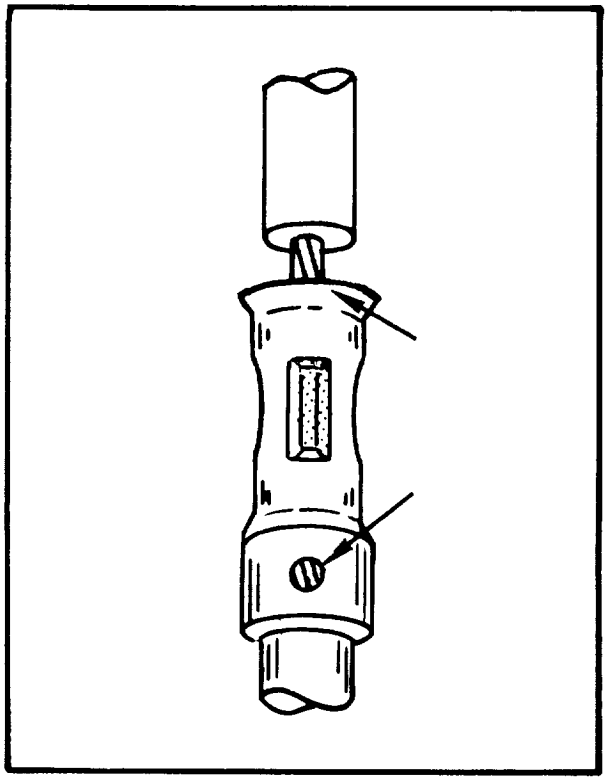


FIGURE B-3

ACCEPTABLE

Care should be taken when seating contacts in the crimping tool. The tool indentors should crimp the contact midway between the shoulder of the insulation support and the inspection hole.

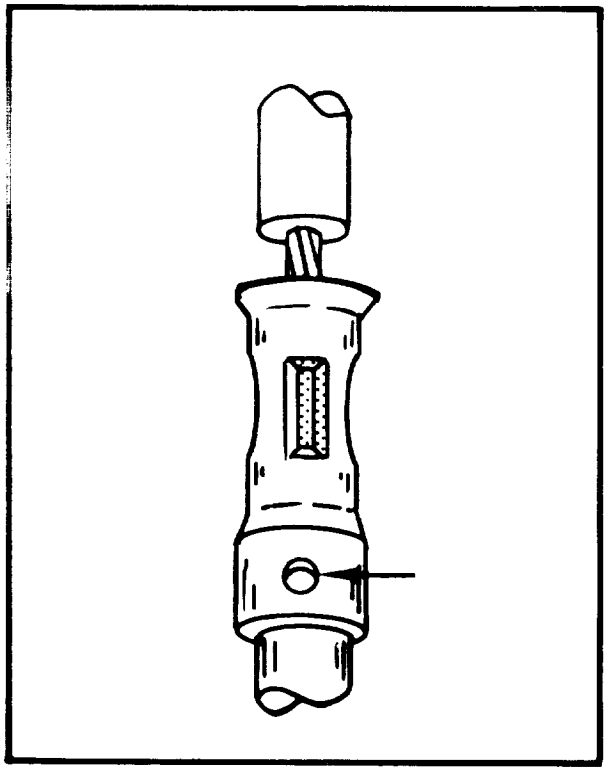


FIGURE B-4

UNACCEPTABLE

If the wire is not stripped back far enough or incorrectly seated in contact, the wire will not be visible in the inspection hole, as shown.

CRIMPS — UNACCEPTABLE

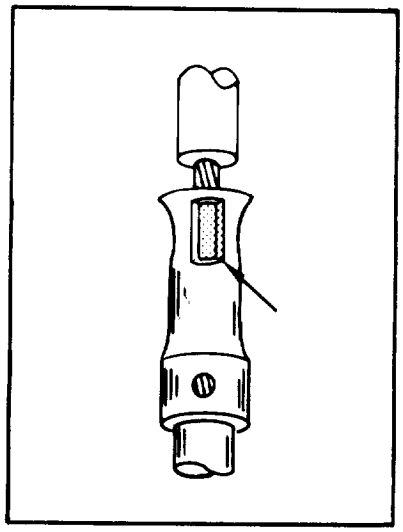


FIGURE B-5A

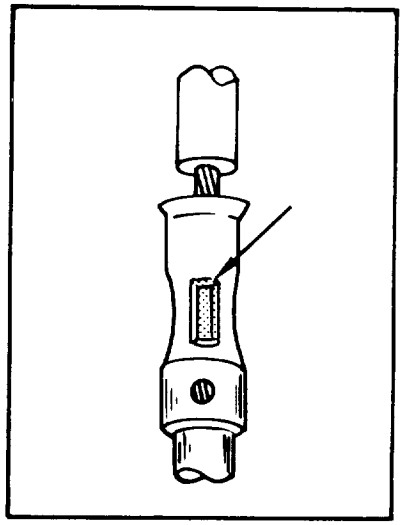


FIGURE B-5B

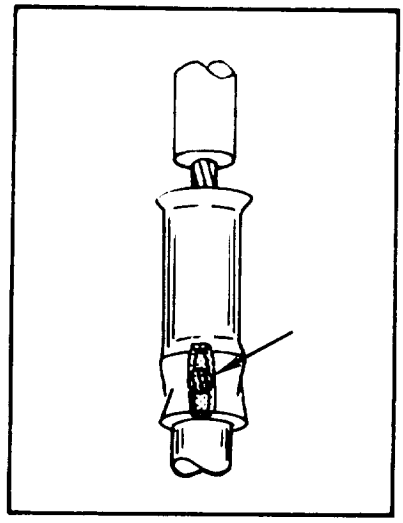


FIGURE B-5C

Failure to properly seat contact in crimping die, or use of incorrect crimping tool will result in improperly crimped contacts. Crimping over the inspection hole or on the radius of the shoulder, as shown, is unacceptable.

UNACCEPTABLE PIN

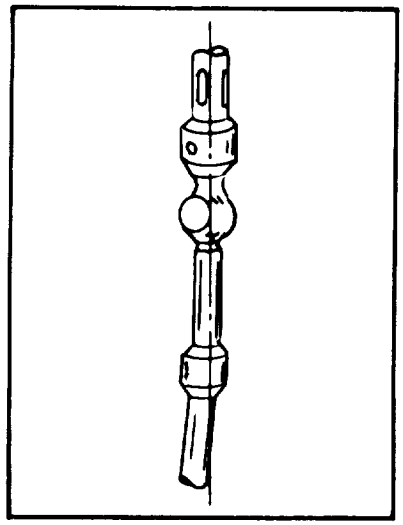


FIGURE B-6

Pins should be checked for alignment. A bent pin, as shown, will not mate with its counterpart and may cause damage to rubber parts of connector.

SOLDERLESS CONNECTIONS — WIREWRAPPED POST, SINGLE—WIRE

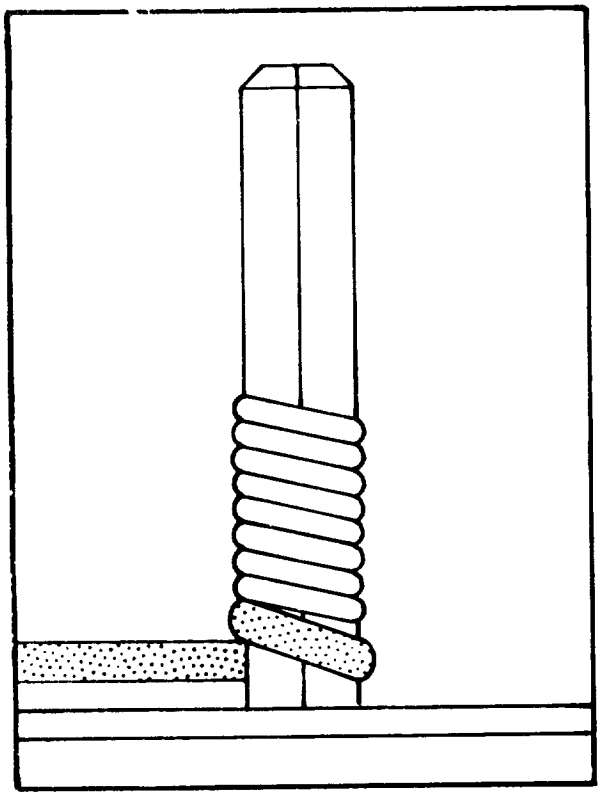


FIGURE B-7

PREFERRED

1. Wrap meets turn requirements (*).
2. Turns are adjacent, and wire end is against post.

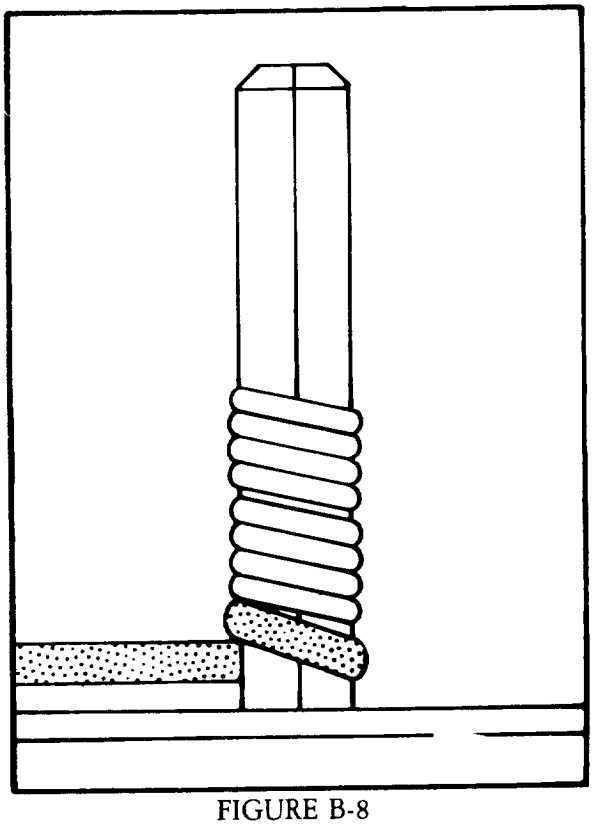


FIGURE B-8

ACCEPTABLE

1. Wrap meets turn requirements (*).
2. Gap between turns does not exceed 1/2 of the conductor's diameter.

(*) NOTE: Minimum requirements for AWG 28 and 30 are 1/2-insulated turn and 7 bare conductor turns.

SOLDERLESS CONNECTIONS — WIREWRAPPED POST, TWO-WIRE

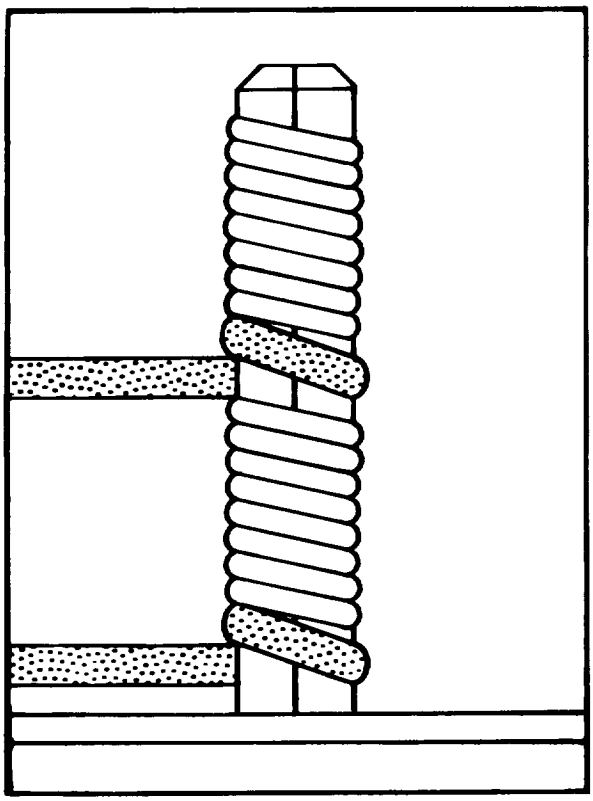


FIGURE B-9

PREFERRED

1. Both wraps meet turn requirements (*).
2. Wraps are separated by a small gap.

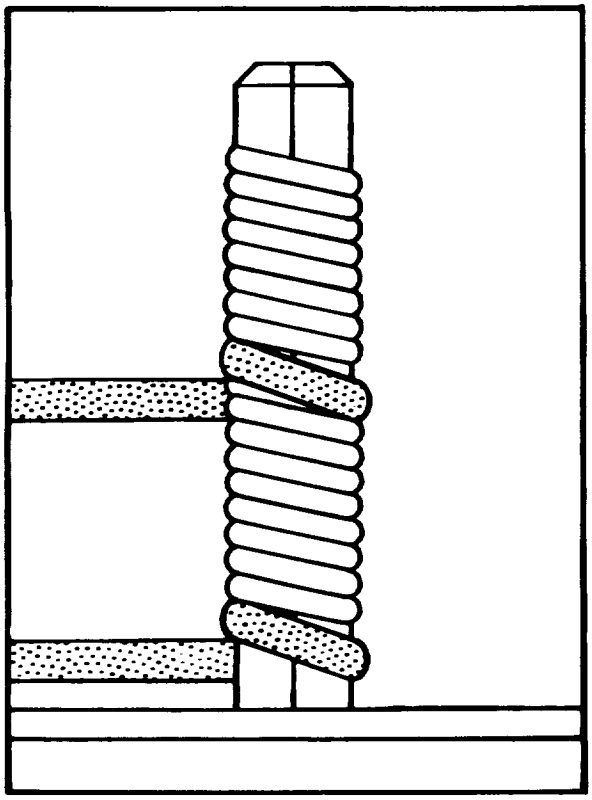


FIGURE B-10

ACCEPTABLE

1. Both wraps meet turn requirements (*).
2. Uninsulated turns of top wrap (on right) do not contact uninsulated turns of lower wrap (on left).

(*) NOTE: Minimum requirements for AWG 28 and 30 are 1/2-insulated turn and 7 bare conductor turns.

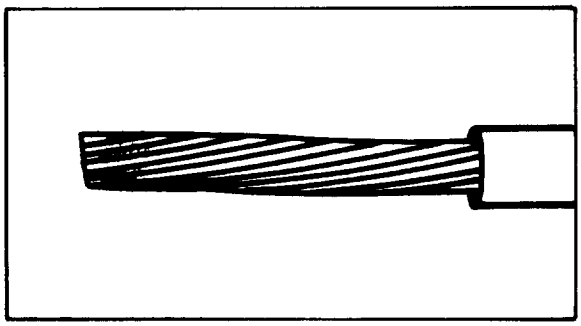


FIGURE B-11

ACCEPTABLE

Wire lay undisturbed: no visible damage to wire strands.

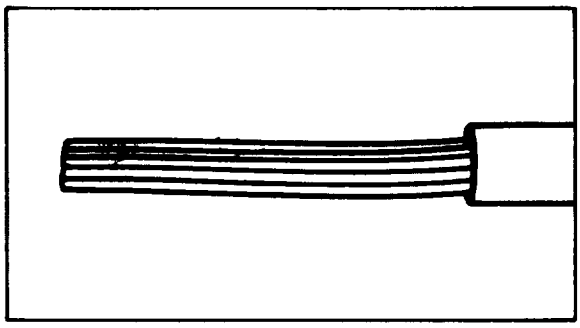


FIGURE B-12

UNACCEPTABLE

Wire strands combed straight. If retwisted to original lay, may be acceptable.

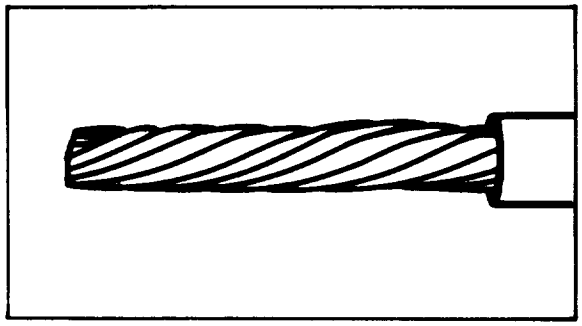


FIGURE B-13

UNACCEPTABLE

Excessive retwist.

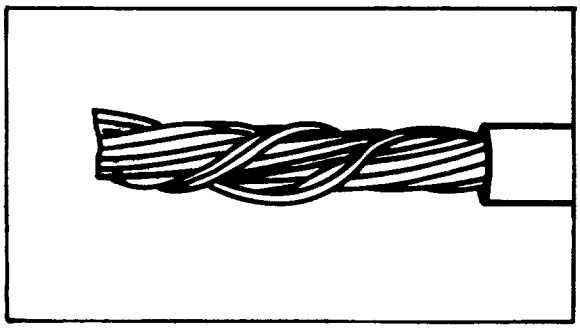


FIGURE B-14

UNACCEPTABLE

Wire strands retwisted in excess of normal lay and overlapped.